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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

LUBRICATION OF
RAILROAD
MOTIVE POWER

PUBLISHED BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

"...BEEN WORKIN' ON THE RAILROAD"

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LUBRICATION

A TECHNICAL PUBLICATION DEVOTED TO THE SELECTION AND USE OF LUBRICANTS

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Lubrication of Railroad Motive Power

Steam Came First

Ever since the first wood-burning steam locomotive scared horses and scattered cinders over the countryside, steam power on wheels has been symbolic of concentrated energy. Other means of transforming energy into useful work often have little or no limitation as to space occupied; the steam locomotive, however, is limited as to width by track gauge, and as to length by grate area and boiler flue. Within an area of some six feet by twenty feet a steam boiler must be located capable of generating some 16,000 pounds of steam an hour for several hours of continuous running. All this for the purpose of making the locomotive a traction machine; which is accomplished by expanding the steam in multiple effect cylinders and linking up the piston rods to turn the driving wheels.

More than two hundred moving parts — each requiring lubrication — must be assembled to run in synchronism to make the modern steam locomotive a workable machine. The layman sees such a locomotive as a massive steam-breathing device — and he is justified in being impressed. The railway engineer, however, remembers the importance of the little things — these 200 odd parts which must be lubricated. Furthermore on a run the locomotive engineer cannot climb all over his machine to check on lubrication, as can be done in stationary service. Even if he could, and did find something amiss, he could not do much of anything to correct the trouble till the end of the run. Locomotives are just not sidetracked like highway vehicles. So road failures are guarded against most carefully by rigid roundhouse inspection at the end of each run, when lubrication is made a major objective.

Then the Diesel Electric Locomotive

In the late thirties a new noise was beginning to be heard on railroads throughout the country. The tuba like horn ot the high speed, high powered, main line Diesel electric locomotive was clamoring for recognition alongside of the already famous deep throated whistle of the steam locomotive. Ever since, the Diesel electric locomotive has been forging ahead to take its rightful place as an important means of motive power.

The Diesel engine has made available concentration of power along with lower center of gravity, and excellent overall efficiency. Its high operating efficiency and high utilization factor have all but doomed the steam locomotive except for special situations. The Diesel electric locomotive is comparable to the electric locomotive except that it carries its own power plant. In both cases, electrical energy is transformed into tractive effort at the traction motors.

Today, American railroads have in operation more than 10,000 main line Diesel electric locomotive units including those used in passenger and

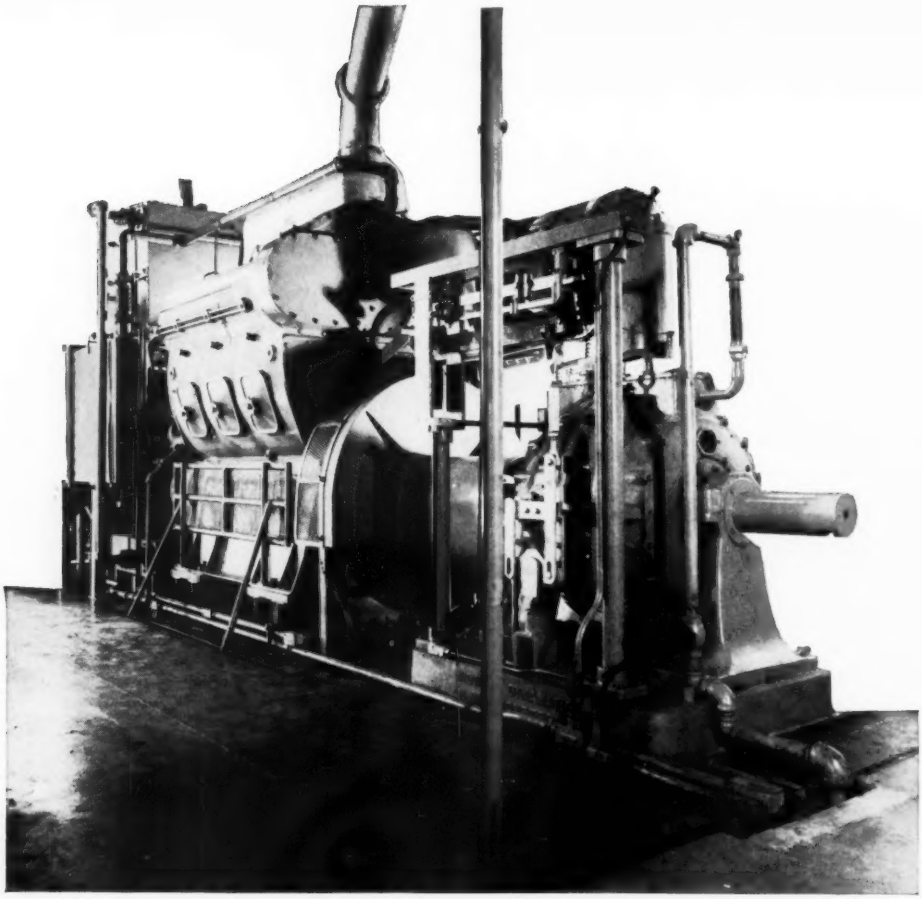


Figure 1 — Showing a full-scale, six cylinder, 660 h.p., Electro-Motive railroad locomotive Diesel engine set-up in the laboratory for study of heavy duty lubricating oils. After each run engine parts are inspected for corrosion or deposits.

freight services. In round figures, this amounts to 16,000,000 horsepower. In addition, there are about 7,000 switching Diesel locomotives in service with a total horsepower rating in the neighborhood of 6,500,000. A total of 22,500,000 railway Diesel horsepower is an imposing figure and shows that this means of motive power has come a long way in a relatively short time.

What promoted the trend away from steam power and towards Diesel power by the railroads? There are two important answers to this question. Economy of operation and availability of equipment. It is well known that, thermally speaking, the Diesel engine burns fuel much more efficiently than the steam locomotive. What is not as well recognized is the fact that the Diesel locomotive is available for service a considerably higher percentage of the time than the steam locomotive. In many cases, Diesel motive power is available for useful work in excess of 90% of the time. The principal reason for this is the fact that the Diesel locomotive does not require as much time for servicing, maintaining, and overhauling as does the steam locomotive.

THE STEAM LOCOMOTIVE

Steam cylinders, valves, and valve seats require lubrication in the steam locomotive. This is internal lubrication; it is maintained automatically by mechanical force feed lubrication actuated by the valve gear, or automatically from a hydrostatic lubricator located in the cab.

Valve Oils

The development of locomotive valve oils has required continued consideration of the progressive increase in steam temperatures and rubbing speeds.

Ordinary steam cylinder oils no longer suffice; the refiner must study the varying operating conditions and apply the best refining techniques for the resultant oil must flow at low temperatures and resist breakdown or partial distillation at high temperatures. It must be spread by the steam and provide a lubricating film on the cylinder walls.

Compounding

Compounding must be considered even though locomotive valve oils are subjected to extremely high temperature conditions. During the course of expansion of the steam a certain amount of condensation develops in the cylinders which necessitates strengthening of the oil film by the presence of a small amount of animal compound which will emulsify with this moisture. As a result, many locomotive valve oils will commonly contain from 3% to 5% of a fatty oil compound.

As the degree of superheat has been raised, however, and as insulating materials have been perfected, the possibility of condensation has been reduced. This, together with improvement in methods of treating boiler feed water, has enabled some railroads operating on very high superheat to lubricate satisfactorily with a highly refined straight mineral valve oil or one containing essentially no compounding fatty material.

Method of Application

Valve oil is injected either directly into the steam pipe above the valve chamber or divided between the steam line and cylinder. In any case, the oil is exposed to the temperature of the steam. On the modern locomotive using highly superheated steam this temperature may range in excess of 700 degrees Fahr. This means that a good superheat valve oil must be so manufactured as to withstand abnormal vaporization under these temperatures.

In addition, the oil must be resistant to oxidation and carbon formation as under certain conditions air may be introduced. This makes it mandatory upon the engineer to see that he does not create a vacuum in the cylinders as otherwise front end gases containing a large amount of air, dirt, and cinders will be drawn in, or fresh air containing oxygen might enter through the relief valve in which case the oil would deteriorate rapidly. With a throttle operated in a cracked position when drifting or coming into station stops, or where the engine is equipped with a drifting valve, there is but little

Figure 2 — Set-up for evaluating lubricants on Westinghouse traction motor bearings. This includes a standard traction motor.

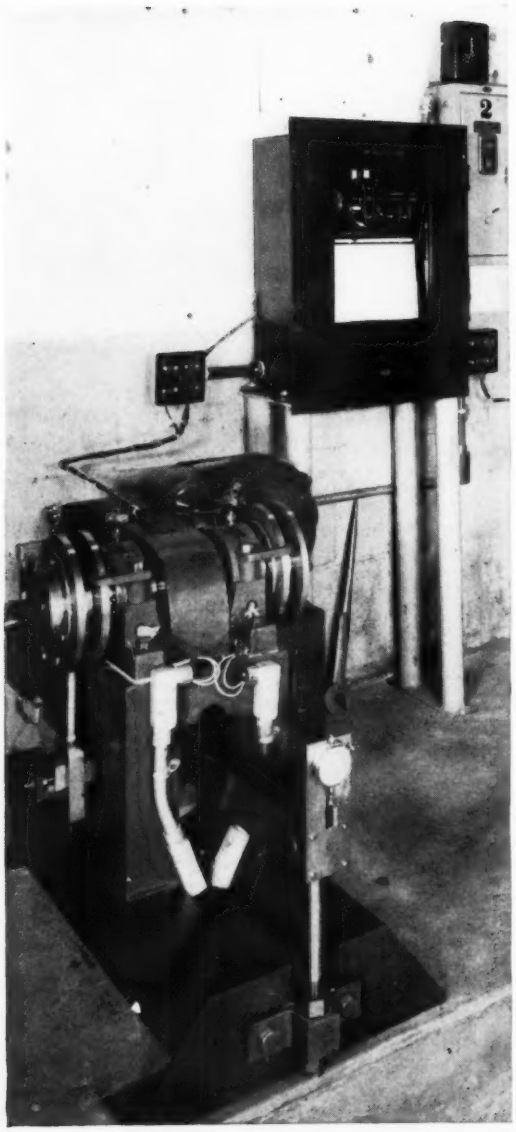


Figure 3 — Subsequently traction motor bearing lubricants are tested on this laboratory SKF machine, being run under load for 24 hours to determine the temperature rise. Heat is then applied and the test continued for 500 hours or until failure of the grease is indicated by noise or abnormal temperature rise.

probability of air entering the valve chamber and cylinders.

THE DIESEL ELECTRIC LOCOMOTIVE

The rapid increase in the use of Diesel motive power by the railroads has posed many problems for the petroleum industry. These problems not only involve supplying large quantities of Diesel fuel and Diesel lubricating oil but also the products furnished must be of first class quality.

Diesel Lubricating Oil

Since the advent of the main line Diesel electric locomotive, there have been many advances made in power plant design. These advantages have come about step by step in true engineering fashion. The results have been engines being placed in service that develop more and more horsepower per cubic inch displacement. Locomotive manufacturers are not slowing down along these lines either. Improved manufacturing techniques along mass production lines coupled with the use of materials which will withstand higher and higher temperatures and pressures are making it possible for still further progress in Diesel locomotive development.

This progress has imposed several problems on lubricating oil performance including:

1. Ring sticking and breakage.
2. Valve sticking and blowing.
3. Wear.
4. Metal corrosion, particularly silver.
5. General engine cleanliness.
6. Rusting.
7. Viscosity build-up.

These problems vary in importance depending upon types of locomotive power whether freight, passenger, or switcher; type of engine whether 2 cycle, 4 cycle, super charged, etc.; and how the power is operated and/or maintained.

When the first Diesel locomotives went into service, power plants were lubricated with straight mineral oils generally of the naphthene variety. Such oils performed extremely well. These oils give a very good account of themselves in later more modern equipment in certain operations. To lubricate the modern Diesel electric locomotive operating in heavy duty service to best advantage, oils with properties enhanced along certain lines are used. Characteristics which a good railway Diesel oil must possess include:

1. Oxidation stability to reduce deposit formation and withstand viscosity build up.
2. Adequate film strength to reduce wear of moving parts to a minimum.
3. Corrosion resistance to prevent acid attack of metals particularly those used in bearings and bushings.
4. Dispersion and detergency to hold contaminating materials in suspension or solution

thereby reducing the tendency to deposit out on engine parts.

5. Certain degree of rustproofing to prevent rusting of metal surfaces during locomotive engine shut-down or temporary storage.

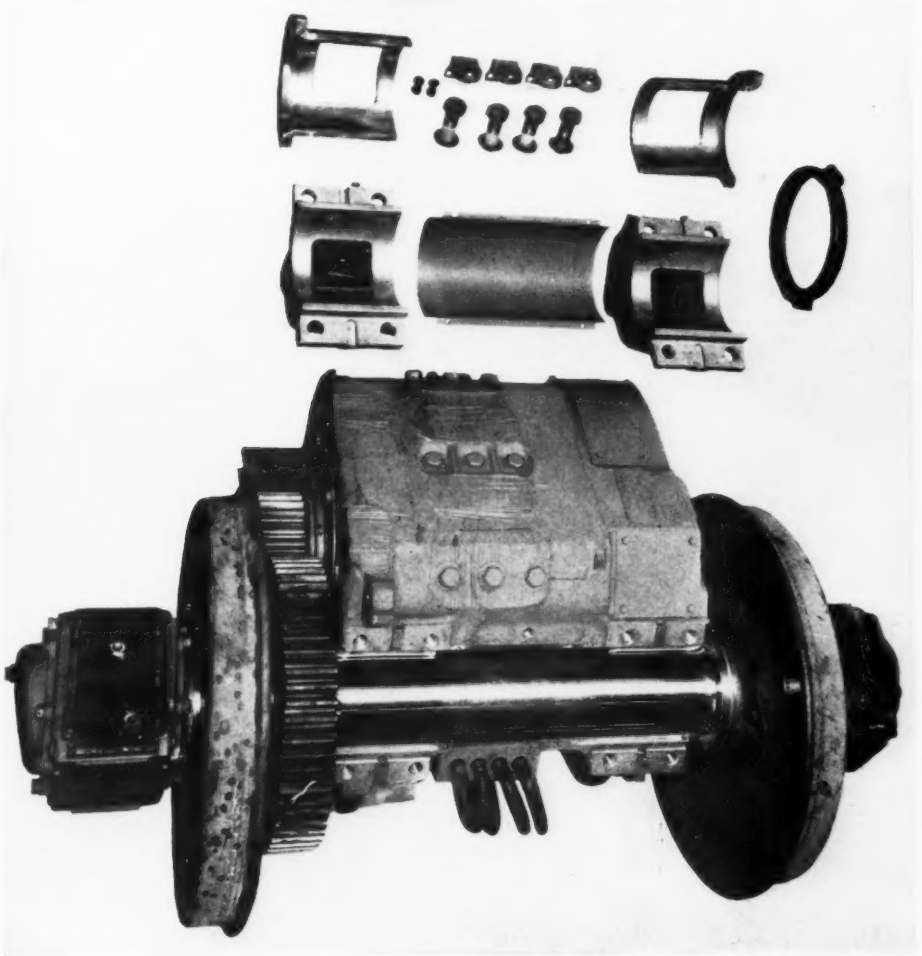
Over the last several years, petroleum research laboratories have learned a great deal about lubricating oil characteristics. They know, for example, how to improve certain properties without interfering with the others in order to provide an oil which will successfully handle a specific lubrication assignment. With regard to Railway Diesel lubrication, improved oils have come into existence by:

1. Selecting base stock from best available crude sources.
2. Refining with processes which will remove all undesirable properties.
3. Incorporating chemical additives that will enhance desirable characteristics in a finished oil.

After the final formulation of an oil has been decided upon it has to be extensively and exhaustively tested in the laboratory under a great variety of conditions, even to the extent of evaluation in a full scale Diesel locomotive engine. See Figure 1. Following this, hundreds of thousands of miles of satisfactory field experience in all types of locomotive Diesels in all types of service must be accumulated before the oil can be considered as entirely acceptable.

THE TRACTION MOTOR

The prime mover in the electric locomotive and an important part of the Diesel locomotive is the traction motor. Electrical power for traction motor operation is furnished by an overhead line or third



Courtesy of American Locomotive Co.

Figure 4 — Cutaway section of a General Electric traction motor showing gear and bearing details.

rail in the case of the electric locomotive and from the Diesel driven generator for the Diesel locomotive. As with other phases of locomotive operation, good lubrication is of primary importance for successful traction motor performance. Loss of a bearing or failure of a gear can mean serious disruption of the time table, a costly repair item, or even actual stopping of the train until a replacement locomotive can be obtained.

Traction Motor Bearings

Roller bearings are used exclusively in traction motors. Some railroads use oil for lubrication of the pinion and commutator bearings while others use grease. The present trend is towards grease lubrication and the goal is for the bearings to run 300,000 miles or from shopping to shopping without any attention. Operating speeds of the electric or Diesel locomotive can be quite high at times and as a result, traction motor bearings can develop relatively high temperatures. With average speeds and loads, the commutator bearings will run at temperatures as high as 150°F. and pinion bearings as high as 190°F.

In oil lubricated bearings, it is necessary to check lubricant level at frequent intervals due to the possibility of leakage. Generally speaking, a good grade of SAE 30 straight mineral oil is used although heavy duty oil has been found to have certain advantages under severe operating conditions where qualities of oxidation stability and extreme pressure come into play.

In grease lubricated bearings, periodic make-up is required except in cases where bearings are sealed. In unsealed bearings a good grade of ball and roller bearing grease will provide entirely satisfactory lubrication. For sealed bearings, the requirements are more stringent. Because one charge of grease must run hundreds of thousands of miles without change or make-up, the grease must possess excellent oxidation stability as well as properties which will resist wear and corrosion of bearings.

Traction Motor Gears

Traction motor gears have to withstand heavy shock loads and at times high speeds. They really "take a beating" when long trains are started particularly during cold weather. Under average oper-

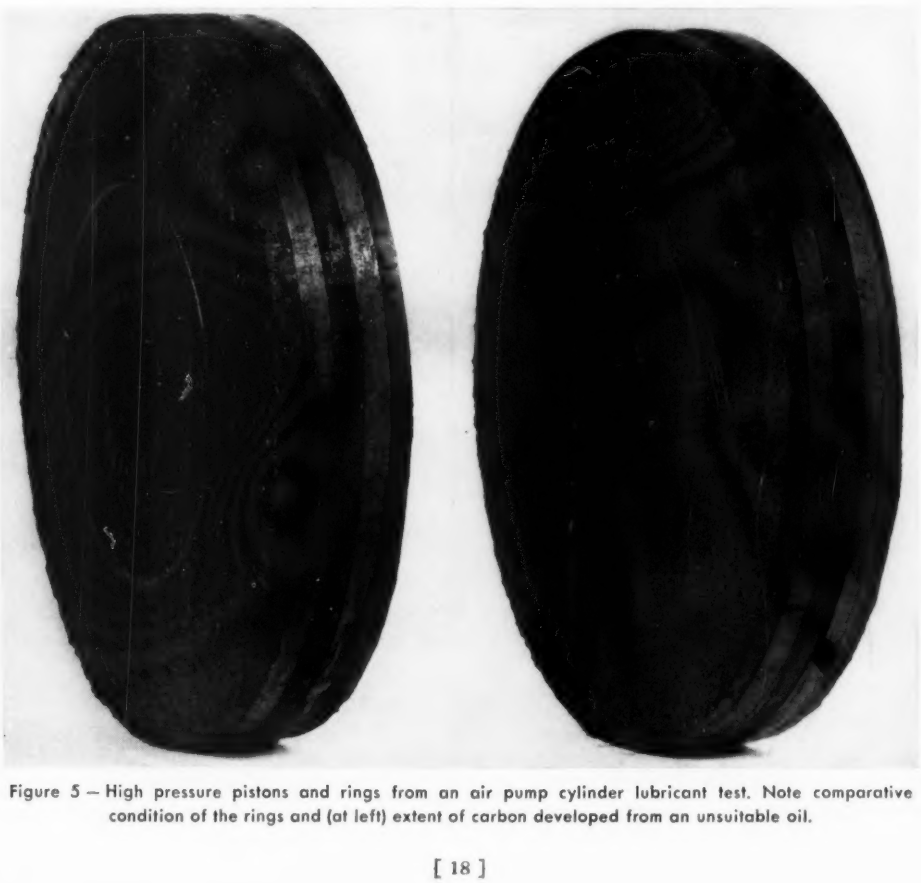


Figure 5 — High pressure pistons and rings from an air pump cylinder lubricant test. Note comparative condition of the rings and (at left) extent of carbon developed from an unsuitable oil.

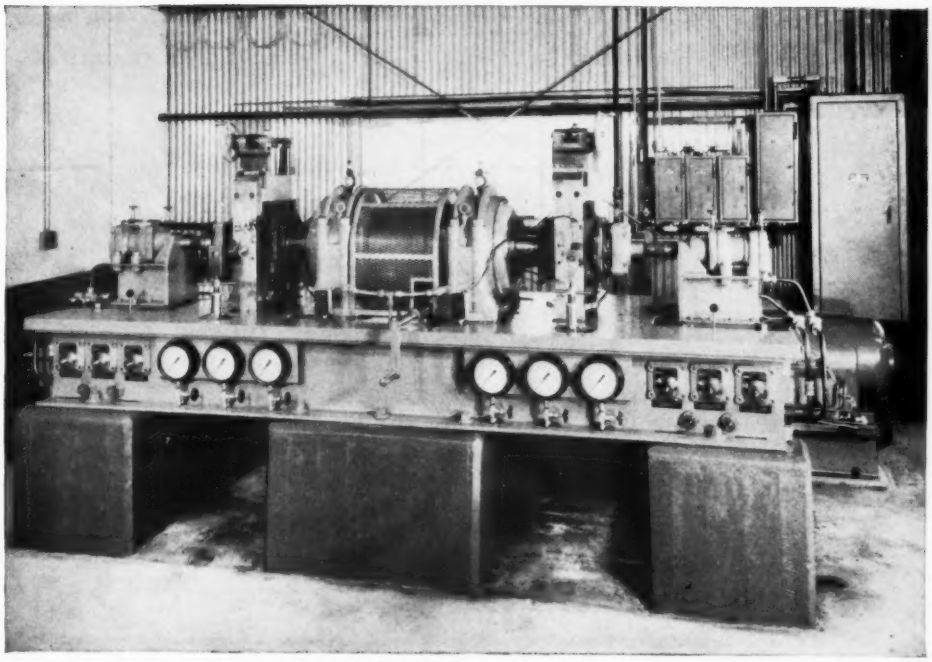


Figure 6 — Railroad journal bearing lubrication test machine. Here steady car loads and shock loads, both vertical and horizontal as involved in regular train operation, can be duplicated in the laboratory by this apparatus which simulates car speeds up to 100 miles per hour.

ating conditions, the gear lubricant may attain a temperature around 175°F. but, of course, will get much hotter under adverse conditions of load and speed.

A gear set includes a small pinion, approximately 6 or 7 inches in diameter, and a large gear, approximately 18 inches in diameter. A comparatively heavy lubricant, approximately 2,000 SSU at 210°F. is introduced through a window at the top of the gear case. About 14 pounds of such a product are required for the initial fill and because of its viscous and adhesive nature may require prior heating before satisfactory application can be made. Overheating of the lubricant, of course, is undesirable as this will cause undue oxidation with resulting thickening or build-up in viscosity. Lubrication of traction motor gears is somewhat troublesome in that gear boxes are not too tight. Thus, lubricant can gradually leak out as a result of the motion of the gears. Lubricants possessing the property of adhesion will resist leakage or throw-out more so than products not having this characteristic. In gear cases where leakage is a factor, track dirt and cinders can also enter resulting in lubricant contamination and possibly excess wear of gears. The gear lubricant must be replenished at frequent intervals — an undesirable chore for the maintenance crew. Tighter gear cases are now making their appearance on many railroads and this, coupled with improved gear lubricants, should simplify servicing and maintenance practices.

AIR PUMPS AND COMPRESSORS

Both these auxiliaries serve to furnish air under pressure for the purpose of manipulating or controlling various locomotive devices such as, brake mechanisms, power reversers, shutter controls, sanders, windshield wipers, whistles, and horns. Railroad parlance refers to the air pump in steam locomotive service and the air compressor in Diesel locomotive service.

Air Pump Lubrication

The air pump on a steam locomotive is similar to the air compressor in stationary service in that it does not require very much lubricant to function effectually. But here the comparison stops for railway locomotive air pumps may run much hotter than stationary air compressors. Accordingly, the lubrication of a locomotive air pump may present a difficult problem, inasmuch as the very small quantity of lubricant required to maintain lubrica-

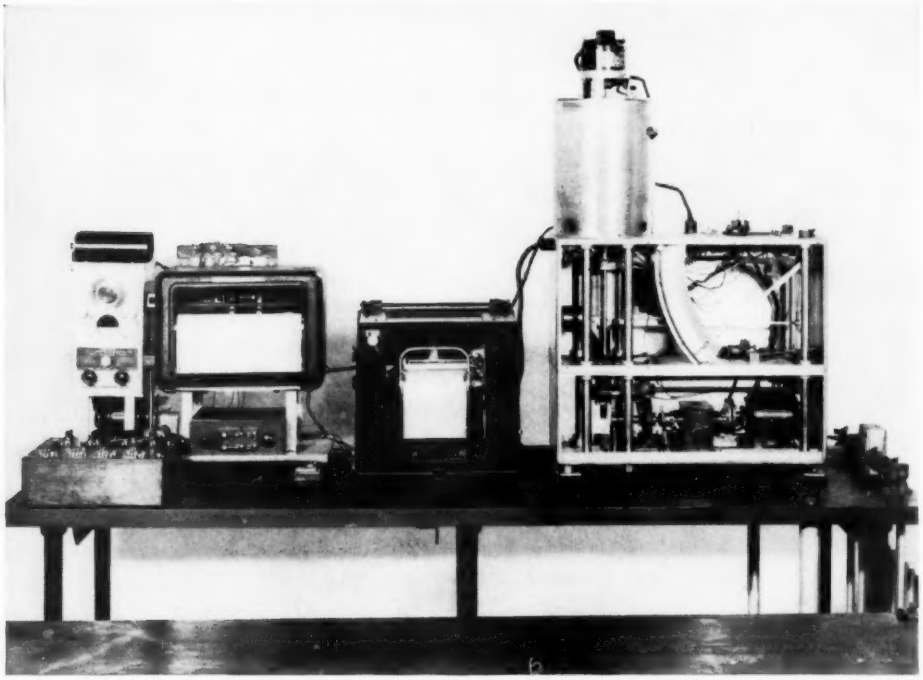


Figure 7 — The McJunkin machine as used for testing driving journal compounds. This machine simulates the action of a follower plate and spring in feeding grease to a driving journal bearing, thereby measuring the feeding characteristics of the product.

tion is subjected not only to extremely high discharge temperatures but also to active oxidizing influences. Temperatures, ranging from 400 to 500 degrees Fahr. normally exist but may go to as high as 800 degrees or more, sometimes reaching red heat.

In general, two classes of lubricants are used:

1. Fluid lubricating oils, and
2. Semi-solid products of the so-called "coolant-colloid" type.

Fluid Oil Lubrication

Straight mineral lubricating oils for locomotive air pump service should be very highly refined, of low carbon-forming tendency, and within a viscosity range which has been proved to be adapted to the means of lubrication available on the locomotives involved.

Roads are getting away from stock valve oils for the air end of the pump because of the higher carbon forming properties of these in comparison with oils of lower viscosity which have very much lower carbon residue contents when properly refined.

Semi-Solid Lubricants

The "coolant-colloid" type of air pump lubricant has been the subject of considerable research. It has gained favor due to its behavior when exposed to high temperatures. As mentioned above, the discharge temperature in a locomotive air pump is exceedingly high. Accordingly, the petroleum technologist had to perfect a lubricant which would have sufficient lubricating ability at these temperatures and yet develop a minimum of objectionable deposits. The ideal was a product which would:

1. Act as a coolant to lower the temperature of the air.
2. Permit minimum formation of deposits; such deposits as might be formed being easily removed with water or steam.
3. Act as a cleansing agent to keep the piston rings and compression chamber clean.

In compounding such a product, in addition to the proper viscosity and type of mineral oil, a coolant and a cleansing agent are incorporated. This combination of ingredients must have the proper consistency to permit use either in automatic

cups or in mechanical lubricators. One of the significant features of the latest research on this subject has been the discovery of cleansing agents which not only have unusual cleansing action, but also vaporize completely when exposed to high temperatures such as exist in air pumps. In this way the cleansing agent, after performing its task of cleansing the cylinder, pistons, piston rings, etc., is itself completely dissipated and, therefore, does not leave objectionable deposits. Accordingly, the cleansing agent functions as such not only in those portions of the cylinder where deposits tend to accumulate, but in the discharge, where the highest temperatures exist and where an ordinary lubricant would be carbonized.

Air Compressor Lubrication

In the Diesel locomotive, power is taken from the engine generally through a flexible coupling to drive a three cylinder, air cooled, compound type air compressor. Two low pressure cylinders mounted in V arrangement, discharge air through an intercooler into the high pressure cylinder which is mounted vertically between two low pressure cylinders. The use of an intercooler reduces the temperature of the discharge air and improves the volumetric and power efficiencies of the compressor.

The air compressor has its own crankcase, oil pump, and pressure lubrication system. The primary purpose of the oil is to lubricate bearings, cylinders, and valves. The oil must be sufficiently viscous to keep rubbing surfaces separated and piston rings sealed. The next most important consideration is to use an oil which will not form carbon deposits on discharge valves since such deposits are the principal cause of valve difficulties.

Improper functioning of discharge valves can cause recompression of hot air and a consequent

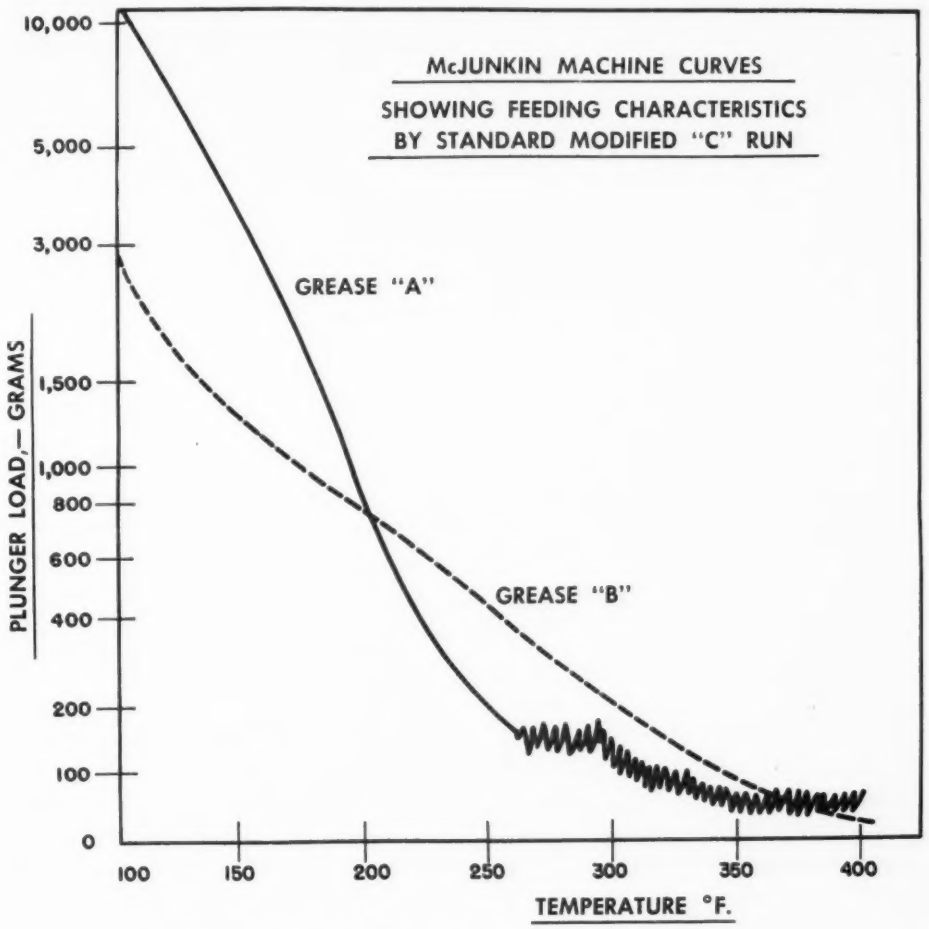


Figure 8 — Typical curves plotted from data obtained on the McJunkin machine.

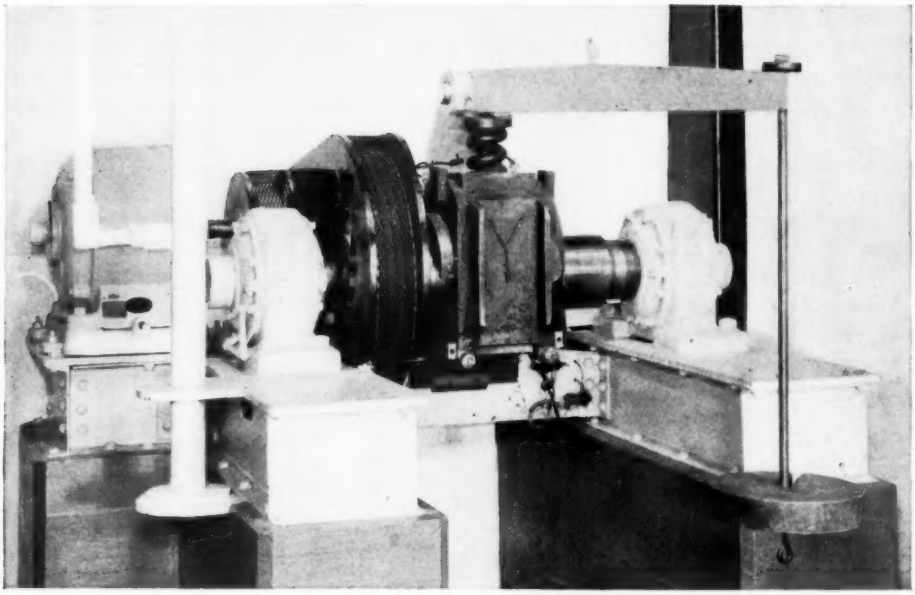


Figure 9 — For testing locomotive driving journal compounds in the laboratory, a unit as above is used to excellent advantage. It involves an actual 9" x 12" bearing and driving box.

build-up in discharge air temperatures. It also means that oil and any entrapped moisture in the air will be carried over into various sections of the air system. This can result in sludge accumulations, for example, in brake lines thereby causing additional operating difficulties.

The air system is a vital factor in the satisfactory performance of any locomotive. Its proper functioning depends upon adequate maintenance and servicing coupled with the use of a good grade of air compressor oil.

DRIVING JOURNALS AND BEARINGS

Driving journal bearings are critical points on any locomotive. On these bearings is concentrated most of the weight of the locomotive. In addition, the bearing surfaces are subjected to very high rubbing speed. During the course of a year's operation, driving journal temperatures will vary from below 0 to about 250°F. In routine service, temperatures in excess of 250°F. are always considered serious. Where this is noted something is wrong either of a mechanical nature or because of faulty lubrication.

1. One of the most prevalent causes of a hot driving box is a stuck or tight wedge. Wedges should be set to a predetermined clearance and this clearance maintained by engine house forces. At the same time, shoes and wedges should be oiled daily to permit free movement of their contact surfaces which other-

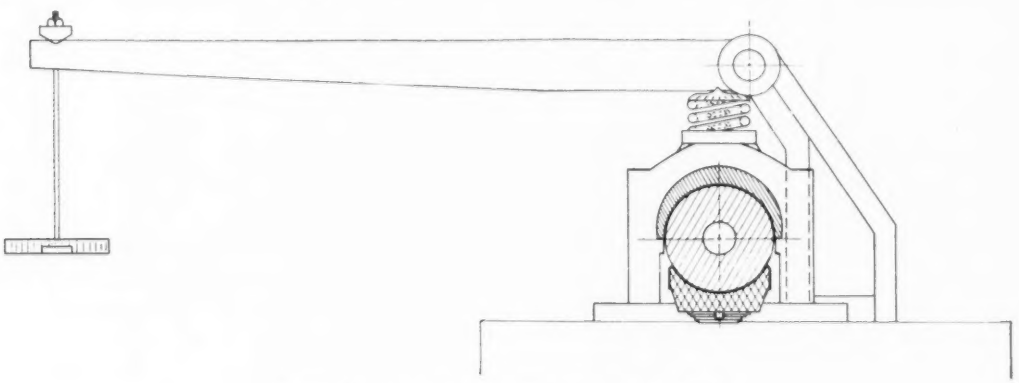


Figure 10 — Line sketch of the set-up shown in Figure 9.

wise would become galled or roughened if allowed to run dry.

2. A crown brass which pinches the journal or is loose in the box, a rough journal or a weak follower plate spring are other major causes of hot driving boxes.
3. The most common cause of a hot driving box is a distorted perforated plate.
4. Faulty lubrication can also result in hot driving boxes because of failure of the grease to feed properly or because of failure of the grease to remain in the box or cellar.

Driving Journal Compound

Early in the game, it was thought that high melting point was the only requirement necessary to insure driving journal grease staying in the housing or cellar without feeding out. Actually, many other factors are involved. The grease must not only be hard enough to stay in the cellar but also soft enough to permit feeding out to lubricate the journal and brasses. The rate of feeding out depends upon the temperatures of the journal and also upon those physical characteristics of the grease which serve to prevent excessive consumption. For example, a product may have a very high melting point yet, due to its particular structure and texture, might show excessive consumption. This could be due to a tendency to pump out or be fanned out by the action of the rotating journal across the perforated plate.

The heat generated in the average journal and bearing assembly is due to the mechanical condition of the assembly. The purpose of the lubricant is to reduce this temperature to a safe operating range. It is true that most greases will serve fairly satisfactorily under mild operating conditions, how-

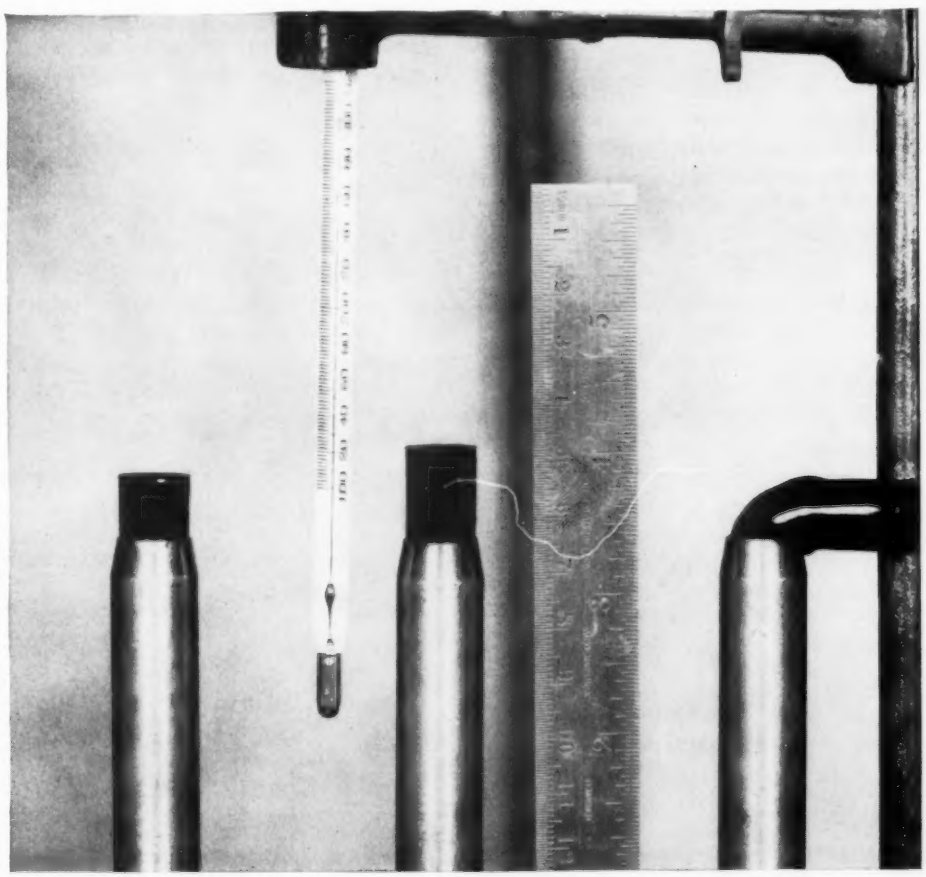


Figure 11 — Results from a rod cup grease expansion test. In this test metal cylinders are filled with rod cup grease and heated gradually in an oven. The measure of the suitability of a product is its tendency to expand. The least expansion is shown by the most suitable grease, see tube at left.

ever, on hot running journals those driving journal compounds which have the highest resistance to heat as well as to pumping action will stay in longer and will permit completion of a run without a set-out.

The ideal driving journal grease, therefore, is one which is as soft as possible at normal temperatures and yet retains its body at higher temperatures. If the grease is too hard, it will not start feeding soon enough and may cause damage to the journal and the brass. A softer type of driving journal compound will allow some lubrication even when the journals are cold. By incorporating in lubricants of this latter type the desired heat resistance at higher temperatures, the ideal lubricant is obtained. In fact, it is possible to make greases softer than the ordinary driving journal compound at room temperature, yet when heat is applied they will actually have more body or consistency than greases which were made very hard originally.

Rod Cup Greases

Rod cup greases were developed along with driving journal compounds. Here again the petroleum technologist had to incorporate the quality of heat-resistance in his product. At the same time, the locomotive designer worked towards improving the design of his pin and bushing assembly.

Modern motive power is, in general, equipped with floating bushings in the back end of each main rod and middle connection. This distributes the load over an increased bearing area and reduces the frictional heat between the moving parts. Design of pin and bushing assembly has played an important part in reducing hot pins, bushing renewals and grease consumption.

Rod cup lubrication presents a problem only on roads where engine districts have been extended, speeds increased, and station stops shortened or eliminated. To insure against lack of lubrication under such conditions, the back end of the main rods, also the middle connections should be greased at some intermediate point if the engine is run at top speed for over 400 miles, in order to replenish the original supply of grease to the rods. The same lubricant as used on the driving journals can be used for lubrication of pins.

Hot pins usually result from fitting the bushings too tightly on the pins or from lack of sufficient lateral.

CONCLUSION

Railroad locomotive lubrication has come a long way since the tallow pot days. Today it is in reality a science and one of the vital factors in timetable maintenance. The petroleum chemists and technologists have contributed markedly to this progress. In the development of the required lubricants it had to be borne in mind that such products had to be possessed of specific characteristics in accordance with design, means of application and operating conditions. This required road test research along with laboratory study. The history of most of the successful railroad lubricants today deals with research of this nature. Volumes of test data, performance charts and mileage records are on file as evidence of the extent to which the petroleum technologist correlated his laboratory research with locomotive road service.

RAILWAY MOTIVE POWER LUBRICATION REQUIREMENTS

Steam Locomotives

Parts to be Lubricated	*Type of Lubricant*
Steam Engine Valve Gear Water Pumps	Valve Oil
Air Pumps	Air Pump Lubricant
Air Brakes	Brake Cylinder Lubricant
Driving Journals (Plain)	Driving Journal Compound
(Roller)	Heavy Valve Oil
Connecting Rod Pins	Rod Cup Grease
Head Light Generators	Roller Bearing Grease or Oil
Side Rods and Fittings	Pressure Gun Grease

Diesel Electric and Electric Locomotives

Parts to be Lubricated	*Type of Lubricant*
Diesel Power Plant	Diesel Engine Oil
Generator Bearings Traction Motor Bearings	Roller Bearing Grease or Oil
Traction Motor Gears Direct Drive Gears	Gear Lubricant
Air Compressors	Air Compressor Oil
Air Filters	Air Filter Oil

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